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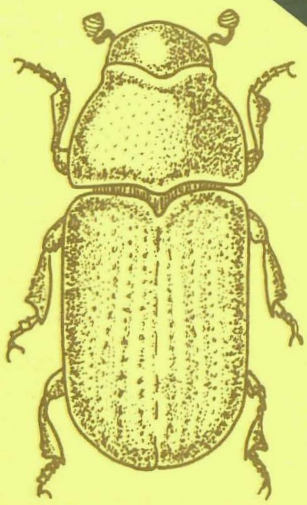
BIOLOGICAL EVALUATION
Tree Damage

Inn of the Mountain Gods
Golf Course
Mescalero Apache Indian
Reservation
New Mexico

1980



Southwestern Region

U. S. DEPARTMENT OF AGRICULTURE

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Region 3

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Forest Pest Management
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INTRODUCTION

The Inn of the Mountain Gods is located on the Mescalero Apache Indian Reservation in southeastern New Mexico at an altitude of about 7,000 feet. The average annual precipitation for the area is 21 inches, half of which occurs as rain from frequent summer thundershowers in June, July, and August. An 18-hole golf course was built around two drainages that feed into a man-made lake near the Inn. Besides providing hazards for several golf holes, this lake is the source of irrigation water for the course. The vegetation on and near the course consists primarily of ponderosa pine in all age classes, from sawtimber to saplings and seedlings, found in stands between the golf holes and as single trees in fairways and around the greens. Since the fall of 1978, the golf course had been irrigated every night during April through September; 2.5 inches per week on the greens and 1.25 to 1.5 inches per week on the fairways.

THE PROBLEM

In the fall of 1979, several ponderosa pines located at the end of a fairway drainage appeared to be fading. By spring of 1980, two trees appeared to be already dead while others were rapidly turning brown. The symptoms first appeared as flagged branches scattered throughout the live crown. While many trees turned completely brown within 2 weeks, some of the larger pines never went past the flagged branch stage.

Examination of the trees yielded no insects or biotic pathogens, and golf course records of cultural practices showed no applications of either herbicides or fertilizers that could have caused such damage. Because the symptoms closely resemble those caused by water or salt excess, samples of soil, irrigation water, and foliage were tested in order to determine which, if either, was the cause of the problem.

METHODS AND RESULTS

Soil and irrigation water were analyzed by the Bureau of Indian Affairs (BIA) Soil, Water, and Materials Testing Laboratory in Gallup, New Mexico; foliage samples were analyzed by the Agronomy Department, New Mexico State University, Las Cruces, New Mexico. Samples were taken from the major drainage of the golf course which contained a majority of the affected trees; trees that ranged from those that were completely brown to those having just a few flagged branches (Figure 1).

Soil

Two soil samples were taken from the golf course: one from an area on a side slope of the main drainage in a stand of trees that appeared

to be healthy, and a second from a pit excavated beneath a tree exhibiting severe damage. This pit was excavated to a depth of about 8 feet; the soil was mainly clay in texture, with signs of an impermeable layer about 4 feet down. The results of the analyses are outlined in Table 1.

The sample taken from near healthy trees can be described as a normal soil with respect to salinity and alkali when compared with other soils in the Southwest. The sample from near the severely affected trees is also considered a normal soil, but contains much larger amounts of sodium and chloride than sample 1.

Water

The irrigation water for the golf course comes from a lake on whose shore the Inn and golf course were built. The golf course drains into the lake. The results of the analyses of the irrigation water are shown in Table 2. According to the U. S. Salinity Laboratory (2), it is medium-saline water. This type of water can lead to saline soil conditions if leaching and drainage of the soil are inadequate. The amounts of bicarbonates (HCO_3), sodium (Na), and chloride (Cl) are not usually considered high, but could cause problems if large amounts of water are used and soil drainage is insufficient.

Foliage

Because the test results from the soil and water indicated that there might be a problem with the soluble salts in the water, 11 foliage samples of various damage levels were tested for chloride content. In other areas, increasing levels of chloride in leaves have been correlated to increased levels of damage of the leaves (1, 3). The following criteria were used in describing the various damage categories:

Control - green, healthy looking foliage.
Light damage - 1 percent to 10 percent of the live crown showing symptoms, i.e., brown needles.
Moderate damage - 10 percent to 50 percent of the live crown showing symptoms.
Heavy damage - more than 50 percent of the live crown showing symptoms.

The sample consisted of twigs and needles from branches that could be reached from the ground. Results of the analyses are listed in Table 3.

DISCUSSION

As the soil sample results show, the Na and Cl content of the soil near the affected trees is higher than the soil sampled near healthy

looking trees. The most logical source for this salt is the irrigation water. Reports from Texas (3, 4) indicate that water with as little as 45 parts per million chloride can cause damage and even death to trees when large amounts of water are used. The electrical conductivity of the water (EC X 10^6 at 25° C), a measure of the amount of soluble salts, is 900, a figure that puts it into a medium/high salinity category. Such water should not be used for irrigation on soils with restricted drainage according to the Salinity Laboratory (2). Large amounts of water alone have caused tree mortality by interfering with the selective uptake capability of the roots (3). Finally, the amount of chloride found in the needles of damaged trees increases directly with the severity of the symptoms. Damage to needles and leaves occurs in the 1,000 to 2,000 parts per million chloride in many species of trees (1, 3).

We believe the cause of the damage to be the large amounts of medium-saline water applied to the golf course. Because of the poor drainage capacity of the soil, salts are building up to high levels in the soil and to damaging levels in the needles.

ALTERNATIVES

1. Do nothing. If large amounts of water are used to keep grass on fairways and greens alive, further damage can be expected with an attendant visual and physical deterioration of a valuable revenue-producing resource. Over a period of years, most of the ponderosa pines located in the irrigated areas of the golf course would be damaged to some degree. Because individual trees react variably to salt damage, it is difficult to predict the intensity of possible damage or the number of trees that may be killed or damaged. Those trees located in low-lying areas and those near the greens would be most likely to be affected because of the amount of water they are receiving.

2. Improve the drainage of the golf course soil by installing sub-soil tile drains and chemically amending the soil to counteract the effects of salt buildup. Large amounts of water applied to a well-drained soil will tend to leach out soluble salts instead of increasing soil salinity. In order for this method to be effective, all areas on the golf course with high clay content, i.e., poor drainage soil, would have to be treated. A complete soil survey of the course would be needed to identify these areas. Because of the size of the area involved, this alternative may be prohibitively expensive. As the sub-soil drainage might take several years to install, the addition of sulfur, gypsum, or ammonium sulfate to the course will help alleviate problems due to salts already present. Trees already severely damaged would probably be lost, and, until the treatment was complete, isolated susceptible trees would be damaged.

3. A reduction on the amount of irrigation water applied combined with a careful monitoring of any damage to grass and trees. Monitoring would consist of weekly records of inches of water applied, monthly reports on the health of trees and grass, and monthly testing of symptomatic tree foliage for chloride content. The purpose of these records is to establish a threshold application rate of irrigation water below which no tree damage occurs, yet which still maintains healthy grass on greens and fairways. Since the tests were conducted, a new watering regime has reduced the amount of water applied weekly. Most of the trees seem to be recovering and are putting out new, healthy foliage. However, 3 to 4 trees have died and others may have been weakened enough to die later.

RECOMMENDATION

We recommend alternative 3.

LITERATURE CITED

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3. Van Arsdel, E. P. 1979. Symptoms and conditions of environmental tree disease. Weed, Trees, and Turf (June 1979): 16-29.

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Figure 1.--Sample area on the golf course with trees showing typical symptoms.

Table 1.--Chemical analysis of golf course soil samples.

	Depth (inches)	Texture % Sand	Silt	Clay	SAR 4/	pH	Milliequivalents 1/ per liter Ca + Mg	Na	K	Cl	PPM 2/ Cl	EC X 10^3 3/ at 25°C
Sample 1												
(No damage)	0-13	28	30	42 = CL	0.58	6.6	8.50	1.20	0.21	0.87	31	0.89
	13-25	16	22	62 = CL	1.33	7.0	4.50	2.00	0.03	0.87	31	0.62
	25-45	8	42	50 = SiCL	1.03	7.2	16.00	2.90	0.03	0.87	31	1.78
Sample 2												
(Damaged	0-13	30	35	35 = CL	1.04	7.0	14.50	2.80	0.58	2.37	84	1.59
trees)	13-25	18	59	41 = SiCL	0.95	7.2	35.50	4.00	0.18	2.37	84	2.79
	25-45	42	29	29 = CL	0.75	7.2	30.00	2.90	0.19	1.87	66	2.39

1/ Milliequivalents per liter. One-thousandth of an equivalent of an ion or a compound in 1 liter of solution. Equivalent is the weight in grams of an ion or compound that combines with or replaces 1 gm of hydrogen. The atomic weight or formula weight divided by its valence.

2/ PPM = Parts per million.

3/ EC X 10^3. Electrical conductivity. The reciprocal of the electrical resistivity. The resistivity is the resistance in ohms of a conductor, metallic or electrolytic, which is 1 cm long and has a cross-sectional area of 1 cm^2. EC is expressed in reciprocal ohms (mhos) per centimeter. The EC of a soil or water sample increases with salt content.

4/ SAR. Sodium - Adsorption - Ratio. A ratio for soil extracts and irrigation waters used to express the relative activity of sodium ions in exchange reactions with soil.

$$SAR = \frac{Na^{+}}{\sqrt{(Ca^{++} + Mg^{++})/2}}$$, where the ionic concentrations are expressed in milliequivalents per liter.

Table 2.--Chemical analysis of golf course irrigation water.

	EC X 10^6 at 25° C	SAR	pH	Milliequivalents per liter (meq/l)					
				HCO_3	Ca	Mg	K	Na	Cl
Sample 1	900	1.28	8.1	1.92	2.65	1.30	0.07	1.80	1.30
				Parts per million (PPM)					
				117.16	106.21	31.62	2.74	41.80	46.10

Table 3.--Chemical analysis of affected foliage.

	PPM Cl										
	Sample Number										
Type of Damage	1	2	3	4	5	6	7	8	9	10	11
Control	939	957	1258								
Light damage				1028	1418	1826					
Moderate damage							2038	2340	2878	3350	
Heavy damage											3403

PPM = Parts per million